The MUSE Network: current status and future developments

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Abstract

This communication presents an overview of the MUSE Research Training Network. The MUSE project is funded by the European Commission and involves six European universities and five industrial partners in a cooperative research and training programme over a period of four years in the area of unsaturated soil mechanics. The research activities include laboratory testing, constitutive modelling, numerical analysis and application to boundary value problems. The training activities include the participation of experienced and early stage researchers (some of them recruited by using funds from the project) in the research undertaken by network partners and a programme of trans-national mobility through workshops, schools, hands-on training sessions as well as secondments within the network.

Introduction

The MUSE project (the acronym MUSE stands for "Mechanics of Unsaturated Soils for Engineering") is a Research Training Network funded by the European Commission within the framework of the Marie Curie actions (6th Framework Programme for Research and Technological Development of the European Union) with an overall budget of 1.25 M€. The logo of the MUSE Network is shown in Figure 1.

The project started on December 2004 with a planned duration of four years and aims at undertaking a comprehensive programme of research and training in the area of unsaturated soil mechanics by means of international collaboration between academic and industrial institutions across Europe. The academic institutions involved in the network are: Durham University and Glasgow University in the UK, Ecole Nationale des Ponts et Chaussées in France, Università di Napoli "Federico II" and Università of Trento in Italy and Universitat Politècnica de Catalunya in Spain. The industrial partners are: Geomod in Switzerland, Geotechnical Observations and Wykeham Farrance in the UK, the Provincia di Bolzano in Italy and Terrasol in France. The project is coordinated by Durham University.

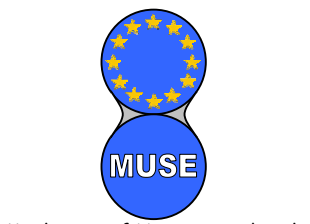

Figure 1 – The MUSE logo

The academic and industrial institutions participating in the network had already experienced close relationships prior to this project, including bilateral agreements and long-term visits or employment of academics at more than one partner institution.

The MUSE network, however, is the first attempt to establish multi-lateral collaborative relationships between these institutions in order to create a critical mass of expertise in unsaturated soil mechanics.

The general purpose of the project is to enable the exchange of knowledge and good practice across different universities in Europe so to address the lack of recognized standards in the procedures for measurement, testing and modelling of unsaturated soils. For this purpose, a research programme has been established where all network partners are involved in the benchmarking of different methodologies and techniques through joint experimental and computational research tasks.

The project is currently in its second year. Seven appointments between experienced researchers (ERs) and early stage researchers (ESRs) have been made so far across the network by using funds from the MUSE project. This corresponds to a total of 204 person/months out of the overall 240 person/months funded by the European Commission. Appointments for the remaining 36 person/months will appear during 2006 and 2007 at Durham University, University of Glasgow and University of Naples Federico II. Details on the eligibility rules for the experienced and early stage researchers can be found on the CORDIS FP6 website (2005) and within the vacancy advertisements that will be published in due course on the MUSE website (2005).

Network activities

Research

A particular advantage of the MUSE project is given by the geographical spread of network partners across Europe, which is reflected in the variety of unsaturated soil types studied by the different research groups. Research groups from southern Europe, where climate is relatively arid and water table is at a considerable depth, have larger direct experience of natural unsaturated soils in comparison with research groups from northern Europe, where natural soil formations tend to be saturated almost up to ground level. On the other hand, research groups from northern European have a larger tradition than colleagues from southern Europe of studying compacted soil, which is widely used as a construction material and tends to remain unsaturated while experiencing significant suction changes during its life. In this respect, the project contributes to the transfer of knowledge between different research groups working with different categories of unsaturated soils and, therefore, experiencing different aspects of material behaviour.

The research programme consists of a wide range of activities framed in four tasks as outlined below.

Task A (Laboratory Testing) includes the generation of a large database of experimental results on the engineering behaviour of different categories of unsaturated soil. This has been achieved by classifying data from laboratory tests on different unsaturated soils already available at the various institutions as well as by performing additional experimental programmes on unsaturated soil under suction controlled (or measured) conditions. Additional tests will investigate specific features of unsaturated soil behaviour such as the effect of suction on small strain stiffness and the role of degree of saturation and temperature on the engineering response of soils.

Task B (Constitutive Modelling) is devoted to the development and validation of constitutive models for unsaturated soils and to the improvement of current models. The network aims at developing constitutive models to enhance the current representation of particularly complex material features, such as the coupling between the hydraulic and mechanical response of the soil and the behaviour under cyclic or

dynamic loading. Different constitutive models will also be developed to accommodate specific material characteristics such as anisotropy, bonding and double-structure.

Task C (Numerical Analysis) aims at developing and validating advanced numerical techniques applicable to the general problem of coupled hydro-mechanical analysis of three-phase granular media. Developments will include the proposal of new algorithms for the integration of complex elasto-plastic stress-strain relationships (see Task B) and their implementation in finite element codes. Further investigation will focus on the performance of finite element codes in the analysis of problems that involve hydro–thermo–chemo-mechanical coupling.

Task D (Application to Boundary Value Problems) is aimed at the application of the constitutive and numerical modelling capabilities for unsaturated soils to a range of practical problems in civil engineering. This will involve the application of constitutive models and computational methods to geotechnical and geoenvironmental cases histories relevant to unsaturated soil, e.g. nuclear waste disposal, underground pollution and slope instability. There will also be at least one original case history for which field instrumentation data will be made available to partners for comparison with a "Class A" model prediction.

One further objective of the network spanning all four tasks of the project is the benchmarking of research techniques and methodologies used at the different institutions. Many of the basic methods of engineering analysis in the area of unsaturated soil mechanics are still evolving and geotechnical engineers are lacking standards in the procedures for measurement, testing and modelling of unsaturated soils similar to those for the analysis of saturated soils. To this aim the MUSE project will compare different procedures, models, techniques and computer codes used at different partner institutions to assess the robustness of a particular approach in comparison with alternative ones. Most importantly, it will show whether the same results can be achieved for the analysis of the same problem by different research groups or by using different procedures, models or codes. The ultimate intention of the planned benchmarking exercises is to obtain indications about the appropriateness of a specific approach to be used for a particular research task.

Training

A significant part of the MUSE project focuses on the training of junior researchers in the area of unsaturated soil mechanics. Training and research carry equal weight in the rationale for this project. The importance of the training aspect is perhaps reflected in the official name of "Research Training Network" given to this type of funding initiatives by the EU and in the requirement that more than 65% of the 1.25 M€ funding must be spent in the recruitment and training of new ERs and ESRs at participating institutions. In the MUSE network the training of junior researcher takes place both at individual and network level.

Training at individual level falls mainly under the responsibility of the institution where the researcher is recruited. It is implemented by involving researchers in various investigation tasks under the supervision of senior academics. Training through teaching is also offered in the form of lecture courses on different aspects of unsaturated soil mechanics run by network partners. Finally researchers are strongly encouraged to undertake secondments or visits at those institutions within the network that have significant expertise in their particular area of research.

Training at network level falls under the responsibility of the whole network. It is implemented through the organization of annual workshops, schools and hands-on training sessions attended by all researchers within the network and organized by different partners in rotation. Workshops give researchers the opportunity to present their investigation to all partners. On the other hand, schools and hands-on sessions offer training on theoretical and practical aspects of unsaturated soil mechanics through a series of lectures or applied tutorials. Researchers are also invited to participate to periodic management meetings held by senior academics to evaluate the overall progress of the project. Participation in management meetings is intended to provide junior researchers with some form of training in the area of research management.

Examples of training at the network level are the annual MUSE schools, which include lectures by speakers from both academia and industry. The electronic copies of the presentations given during MUSE schools are made available for download free of charge from the MUSE website (2005). The first MUSE school (*Fundamentals of Unsaturated Soils*) was held at the Universitat Politècnica de Catalunya (Barcelona, Spain) on the 1st and 2nd June 2005. The second MUSE school (*Applied Unsaturated Soils Mechanics*) was held at the Ecole Nationale des Ponts et Chaussées (Paris, France) on the 17th and 18th May 2006. Both these schools were open free of charge to people from outside the network: the first school registered a total of 79 participants including 31 attendees from outside the network whereas the second school had a total of 86 participants including 45 from outside the network. The third MUSE school will be held at the Università di Napoli Federico II in Naples, Italy in June 2007 and will be open to all interested people as the previous two schools.

Conclusions

The MUSE network is a research and training project in unsaturated soil mechanics funded by the European Commission and involving several academic and industrial partners across Europe. The project aims at undertaking a wide investigation programme and intends to provide training for a new generation of geotechnical researchers and practitioners. The research programme encompasses laboratory testing, constitutive modelling, numerical modelling and application to boundary value problems. Important aspects of the MUSE research are the benchmark of testing and modelling techniques as well as the validation of model predictions against field observations. The ultimate aim of all benchmarking activities is to demonstrate the reliability of testing and modelling techniques for unsaturated soils and promoting their use within the industrial sector. The training programme includes activities undertaken at both individual and network level such as workshops, schools and hands-on training sessions held annually at participating universities in rotation. The MUSE schools are open free of charge to all people from outside the network interested in unsaturated soil mechanics. The training activities taking place within the MUSE project intend to improve understanding of unsaturated soil mechanics among the future generation of researchers and geotechnical engineers and, therefore, to promote awareness of the important role of this discipline in civil engineering.

References

CORDIS FP6 website (2005) - European Union , http://www.cordis.lu/fp6.
MUSE website (2005) - MUSE “Marie Curie” Research Training Network, http://muse.dur.ac.uk.